INSTALLATION MANUAL

Geo Direct PWM Amplifier

Direct PWM Amplifier

500-603700-xIxx

November 15, 2013

DELTA TAU
Data Systems, Inc.
NEW IDEAS IN MOTION ...

Single Source Machine Control ..... *Power // Flexibility // Ease of Use*
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Operating Conditions

All Delta Tau Data Systems, Inc. motion controller products, accessories, and amplifiers contain static sensitive components that can be damaged by incorrect handling. When installing or handling Delta Tau Data Systems, Inc. products, avoid contact with highly insulated materials. Only qualified personnel should be allowed to handle this equipment.

In the case of industrial applications, we expect our products to be protected from hazardous or conductive materials and/or environments that could cause harm to the controller by damaging components or causing electrical shorts. When our products are used in an industrial environment, install them into an industrial electrical cabinet or industrial PC to protect them from excessive or corrosive moisture, abnormal ambient temperatures, and conductive materials. If Delta Tau Data Systems, Inc. products are directly exposed to hazardous or conductive materials and/or environments, we cannot guarantee their operation.

WARNING

A Warning identifies hazards that could result in personal injury or death. It precedes the discussion of interest.

Caution

A Caution identifies hazards that could result in equipment damage. It precedes the discussion of interest.

Note

A Note identifies information critical to the understanding or use of the equipment. It follows the discussion of interest.

REVISION HISTORY				
REV.	**DESCRIPTION**	**DATE**	**CHANGE**	**APPROVAL**
1	Added Power On/Off procedures, Power PMAC section, Refurbished entire manual	11/15/2013	RN	RN

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INTRODUCTION

The Geo Direct PWM amplifiers provide a 1- or 2-axis motor power using highly integrated IGBT based power circuitry. They support a wide variety of motors and power ranges. The Geo Direct PWM amplifiers interface directly with Delta Tau's PMAC2 or PMAC3 style digital ASICs, typically found in the axis expansion cards inside a Turbo or Power UMAC rack.

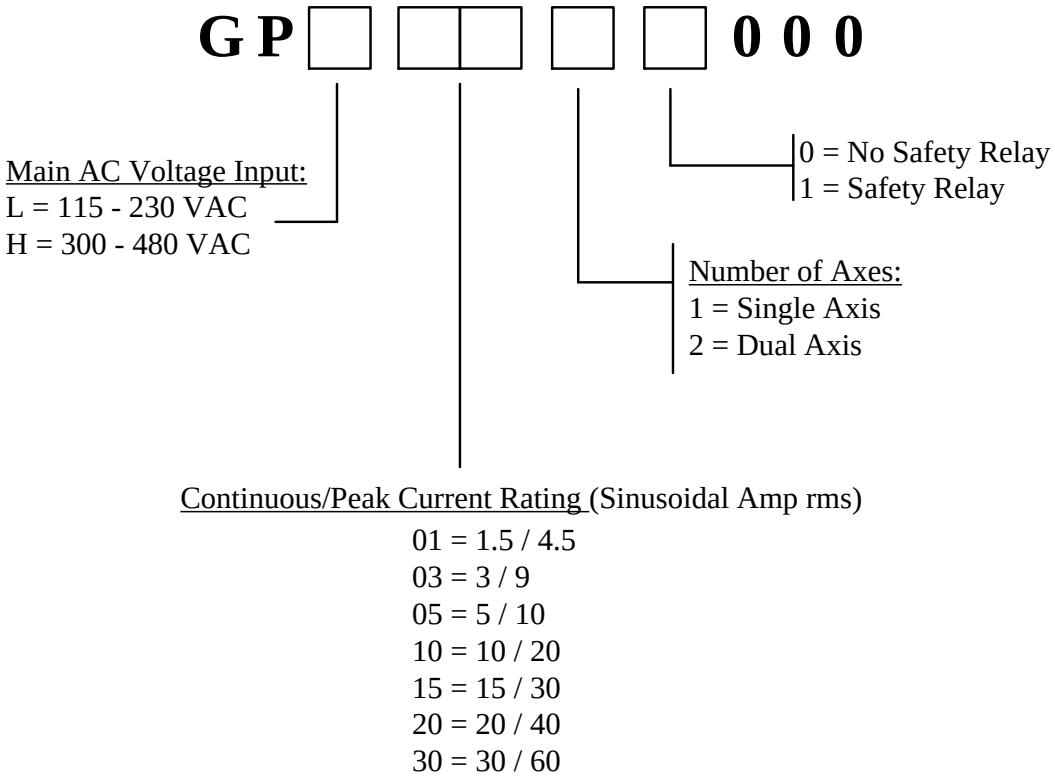
The Geo Direct PWM Drive takes the actual power-transistor on/off signals from PMAC, while providing digital phase-current feedback and status for closed-loop operation. The interface to the direct PWM amplifier is through a standard 36-pin Mini-D style cable.

The Geo Direct PWM amplifiers are capable of driving brush, brushless, or induction motors. They operate in the 100 VAC – 480 VAC (156 – 678 DC) range at 50/60Hz, while providing full protection:

- Over voltage
- Under voltage
- Over temperature
- PWM frequency limit
- Motor over temperature input
- Short circuit (phase – phase)
- Over current
- Safety relay circuit

SPECIFICATIONS

Part Number


G P □ □□ □ □ 0 0 0
Main AC Voltage Input:
L = 115 - 230 VAC
H = 300 - 480 VAC
0 = No Safety Relay
1 = Safety Relay
Number of Axes:
1 = Single Axis
2 = Dual Axis
Continuous/Peak Current Rating (Sinusoidal Amp rms)
01 = 1.5 / 4.5
03 = 3 / 9
05 = 5 / 10
10 = 10 / 20
15 = 15 / 30
20 = 20 / 40
30 = 30 / 60

Environmental Specifications

Description	**Specifications**
Operating Temperature	0 to 45°C Above 45°C,de-rate current output by 2.5% per °C
Storage Temperature	-25°C to +70°C
Humidity	10% to 90% non-condensing
Operating Altitude	~3300 Feet (1000 m) De-rate current output by 1.1% per additional 330 feet (100m)
Air Flow Clearances	~3 inches (76.2mm) above and below unit for air flow
Operating Environment	Pollution Degree 2 or equivalent

Electrical Specifications

230 VAC Drives – Single Axis		GxL051	GxL101	GxL151	GxL201	GxL301
Main Input Power						
Main AC Input	[VAC rms]	$110^{-20\%}$ – $240^{+10\%}$ (~87 – 264)				
Rated Input Current @ 240VAC 3ϕ	[A rms]	3.3	6.6	9.9	13.2	19.8
Frequency	[Hz]	50/60 Hz				
Rated Input Power	[Watts]	1315	2629	3944	5259	7888
Main Bus Capacitance	[µf]	3380			5020	6800
AC Input Phase Requirement		1Φ or 3Φ	3Φ			
Output						
Continuous Current Output per Axis	[A rms]	5	10	15	20	30
Peak Current Output per Axis @ 2 sec	[A rms]	10	20	30	40	60
Power Output per Axis	[Watts]	1195	2390	3585	4780	7171
Bus Protection						
Nominal DC Bus	[VDC]	325				
Over-Voltage Trip Level	[VDC]	410				
Under-Voltage Lockout Level	[VDC]	137				
Shunt Resistor						
Shunt Turn-On Voltage	[VDC]	392				
Shunt Turn-Off Voltage	[VDC]	372				
Shunt Resistor (300 W max)		GAR78	GAR48		GAR48-3	
Logic Power						
Input Voltage	[VDC]	20 – 27				
Input Current	[A rms]	2				
Inrush Current	[A]	4				
Current Feedback						
Full Scale Reading	[A]	16.26	32.53	48.79	65.05	97.58
Resolution	[bits]	12				
Transistor Control						
Recommended PWM Frequency	[KHz]	12		10	8	
Minimum Dead time	[µs]	1				
Charge Pump Time (% of PWM Period)		5				

Note

All values are at ambient temperature of 0 – 45°C (113 F) unless otherwise stated.

230 VAC Drives – Dual Axis		GxL012	GxL032	GxL052	GxL102	GxL152
Main Input Power						
Main AC Input	[VAC rms]	$110^{-20\%}$ – $240^{+10\%}$ (~87 – 264)				
Rated Input Current @ 240VAC 3ϕ	[A rms]	1.98	3.96	6.6	13.2	19.8
Frequency	[Hz]	50/60 Hz				
Rated Input Power	[Watts]	789	1578	2629	5259	7888
Main Bus Capacitance	[µf]	3380				5020
AC Input Phase Requirement		1Φ or 3Φ		3Φ		
Output						
Continuous Current Output per Axis	[A rms]	1.5	3	5	10	15
Peak Current Output per Axis @ 2 sec	[A rms]	4.5	9	10	20	30
Power Output per Axis	[Watts]	359	717	1195	2390	3585
Bus Protection						
Nominal DC Bus	[VDC]	325				
Over-Voltage Trip Level	[VDC]	410				
Under-Voltage Lockout Level	[VDC]	137				
Shunt Resistor						
Shunt Turn-On Voltage	[VDC]	392				
Shunt Turn-Off Voltage	[VDC]	372				
Shunt Resistor (300 W max)		GAR78			GAR48	
Logic Power						
Input Voltage	[VDC]	20 – 27				
Input Current	[A rms]	2				
Inrush Current	[A]	4				
Current Feedback						
Full Scale Reading	[A]	7.32	14.64	16.26	32.53	48.79
Resolution	[bits]	12				
Transistor Control						
Recommended PWM Frequency	[KHz]	16		12		10
Minimum Dead time	[µs]	1				
Charge Pump Time (% of PWM Period)		5				

Note

All values are at ambient temperature of 0–45°C (113 F) unless otherwise stated.

480 VAC Drives – Single Axis		GxH051	GxH101	GxH151	GxH201	GxH301
Main Input Power						
Main AC Input	[VAC rms]	$375^{-20\%}$ – $480^{+10\%}$ (~300 – 525)				
Rated Input Current	[A rms]	3.3	6.6	9.9	13.2	19.8
Frequency	[Hz]	50/60 Hz				
Rated Input Power	[Watts]	2744	5487	8231	10974	16461
Main Bus Capacitance	[µf]	845			1255	1700
AC Input Phase Requirement		1Φ or 3Φ	3Φ			
Output						
Continuous Current Output per Axis	[A rms]	5	10	15	20	30
Peak Current Output per Axis @ 2 sec	[A rms]	10	20	30	40	60
Power Output per Axis	[Watts]	2494	4988	7482	9977	14965
Bus Protection						
Nominal DC Bus	[VDC]	678				
Over-Voltage Trip Level	[VDC]	828				
Under-Voltage Lockout Level	[VDC]	137				
Shunt Resistor						
Shunt Turn-On Voltage	[VDC]	784				
Shunt Turn-Off Voltage	[VDC]	744				
Shunt Resistor (300 W max)		GAR78	GAR48		GAR48-3	
Logic Power						
Input Voltage	[VDC]	20 – 27				
Input Current	[A rms]	2				
Inrush Current	[A]	4				
Current Feedback						
Full Scale Reading	[A]	16.26	32.53	48.79	65.05	97.58
Resolution	[bits]	12				
Transistor Control						
Recommended PWM Frequency	[KHz]	12	10	8		
Minimum Dead time	[µs]	1.6				
Charge Pump Time (% of PWM Period)		5				

Note

All values are at ambient temperature of 0–45°C (113 F) unless otherwise stated.

480 VAC Drives – Dual Axis		GxH012	GxH032	GxH052	GxH102	GxH152
Main Input Power						
Main AC Input	[VAC rms]	$375^{-20\%}$ – $480^{+10\%}$ (~300 – 525)				
Rated Input Current @ 240VAC 3ϕ	[A rms]	1.98	3.96	6.6	13.2	19.8
Frequency	[Hz]	50/60 Hz				
Rated Input Power	[Watts]	1646	3292	5487	10974	16461
Main Bus Capacitance	[µf]	845				1255
AC Input Phase Requirement		1Φ or 3Φ		3Φ		
Output						
Continuous Current Output per Axis	[A rms]	1.5	3	5	10	15
Peak Current Output per Axis @ 2 sec	[A rms]	4.5	9	10	20	30
Power Output per Axis	[Watts]	748	1496	2494	4988	7482
Bus Protection						
Nominal DC Bus	[VDC]	678				
Over-Voltage Trip Level	[VDC]	828				
Under-Voltage Lockout Level	[VDC]	137				
Shunt Resistor						
Shunt Turn-On Voltage	[VDC]	784				
Shunt Turn-Off Voltage	[VDC]	744				
Shunt Resistor (300 W max)		GAR78			GAR48	
Logic Power						
Input Voltage	[VDC]	20 – 27				
Input Current	[A rms]	2				
Inrush Current	[A]	4				
Current Feedback						
Full Scale Reading	[A]	7.32	14.64	16.26	32.53	48.79
Resolution	[bits]	12				
Transistor Control						
Recommended PWM Frequency	[KHz]	12		10	8	
Minimum Dead time	[µs]	1.6				
Charge Pump Time (% of PWM Period)		5				

Note

All values are at ambient temperature of 0–45°C (113 F) unless otherwise stated.

RECEIVING AND UNPACKING

Delta Tau products are thoroughly tested at the factory and carefully packaged for shipment. When the Geo Direct PWM Drive is received, there are several things to be done immediately:

- Observe the condition of the shipping container and report any damage immediately to the commercial carrier that delivered the drive.
- Remove the drive from the shipping container and remove all packing materials. Check all shipping material for connector kits, documentation, or other small pieces of equipment. Be aware that some connector kits and other equipment pieces may be quite small and can be accidentally discarded if care is not used when unpacking the equipment. The container and packing materials may be retained for future shipment.
- Verify that the part number of the drive received is the same as the part number listed on the purchase order.
- Inspect the drive for external physical damage that may have been sustained during shipment and report any damage immediately to the commercial carrier that delivered the drive.
- Electronic components in this product are design-hardened to reduce static sensitivity. However, use proper procedures when handling the equipment.
- If the Geo Direct PWM Drive is to be stored for several weeks before use, be sure that it is stored in a location that conforms to published storage humidity and temperature specifications.

Use of Equipment

The following restrictions will ensure the proper use of the Geo Direct PWM Drive:

- The components built into electrical equipment or machines can be used only as integral components of such equipment.
- The Geo Direct PWM Drive must not be operated on power supply networks without a ground or with an asymmetrical ground.
- If the Geo Direct PWM Drive is used in residential areas, or in business or commercial premises, implement additional filtering measures.
- The Geo Direct PWM Drive may be operated only in a closed switchgear cabinet, taking into account the ambient conditions defined in the environmental specifications.

Delta Tau guarantees the conformance of the Geo Direct PWM Drives with the standards for industrial areas stated in this manual, only if Delta Tau components (cables, controllers, etc.) are used.

MOUNTING, PHYSICAL LAYOUT

The location of the Geo Direct PWM Drive is important. Installation should be in an area that is protected from direct sunlight, corrosives, harmful gases or liquids, dust, metallic particles, and other contaminants. Exposure to these can reduce the operating life and degrade performance of the drive.

Several other factors should be carefully evaluated when selecting a location for installation:

- For effective cooling and maintenance, the Geo Direct PWM Drive should be mounted on a smooth, non- flammable vertical surface.
- At least 76 mm (3 inches) top and bottom clearance must be provided for air flow. At least 10 mm (0.4 inches) clearance is required between units (each side).
- Temperature, humidity and Vibration specifications should also be taken in account.

Caution

Unit must be installed in an enclosure that meets the environmental IP rating of the end product (ventilation or cooling may be necessary to prevent enclosure ambient from exceeding 45° C [113° F]).

The Geo Direct PWM Drive can be mounted with a traditional 4-hole panel mount, two U shape/notches on the bottom and two pear shaped holes on top.

If multiple Geo Direct PWM Drives are used, they can be mounted side-by-side, leaving at least a 122 mm clearance between drives. This means a 122 mm center-to-center distance (0.4 inches) with the 4-axis Drives. 8- and 6-axis Geo Direct PWM Drives can be mounted side by side at 214 mm center-to-center distance (8.4 inches). It is extremely important that the airflow is not obstructed by the placement of conduit tracks or other devices in the enclosure.

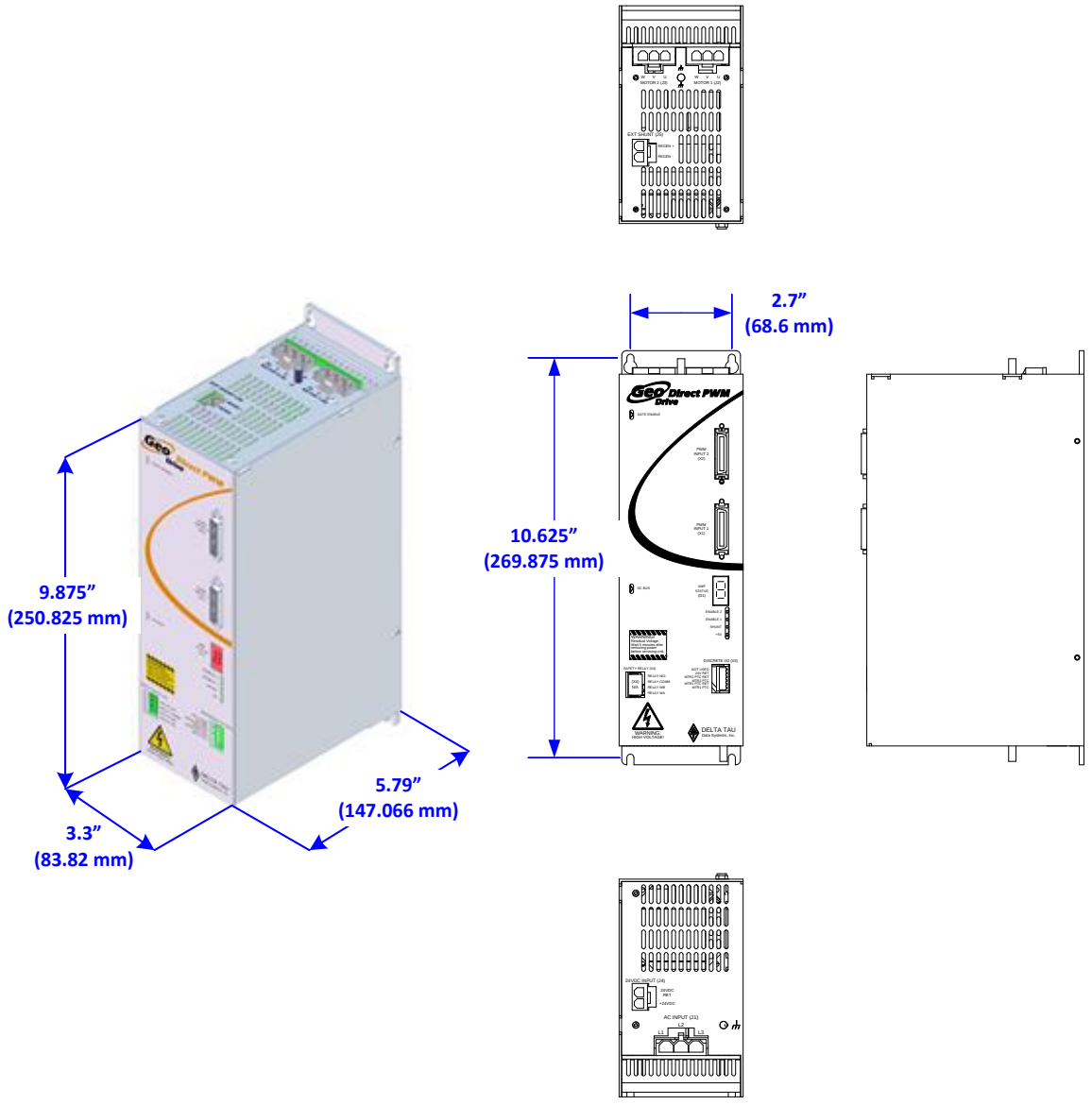
If the drive is mounted to a back panel, the back panel should be unpainted and electrically conductive to allow for reduced electrical noise interference. The back panel should be machined to accept the mounting bolt pattern of the drive.

The Geo Direct PWM Drive can be mounted to the back panel using four M4 screws and internal-tooth lock washers. It is important that the teeth break through any anodization on the drive's mounting gears to provide a good electrically conductive path in as many places as possible. Mount the drive on the back panel so there is airflow at both the top and bottom areas of the drive (at least three inches).

GPx012

Width	Height	Depth	Weight
3.30 in. / 84 mm	11.00 in. / 280 mm	5.80 in. / 147 mm	4.2 lbs / 1.9 kgs

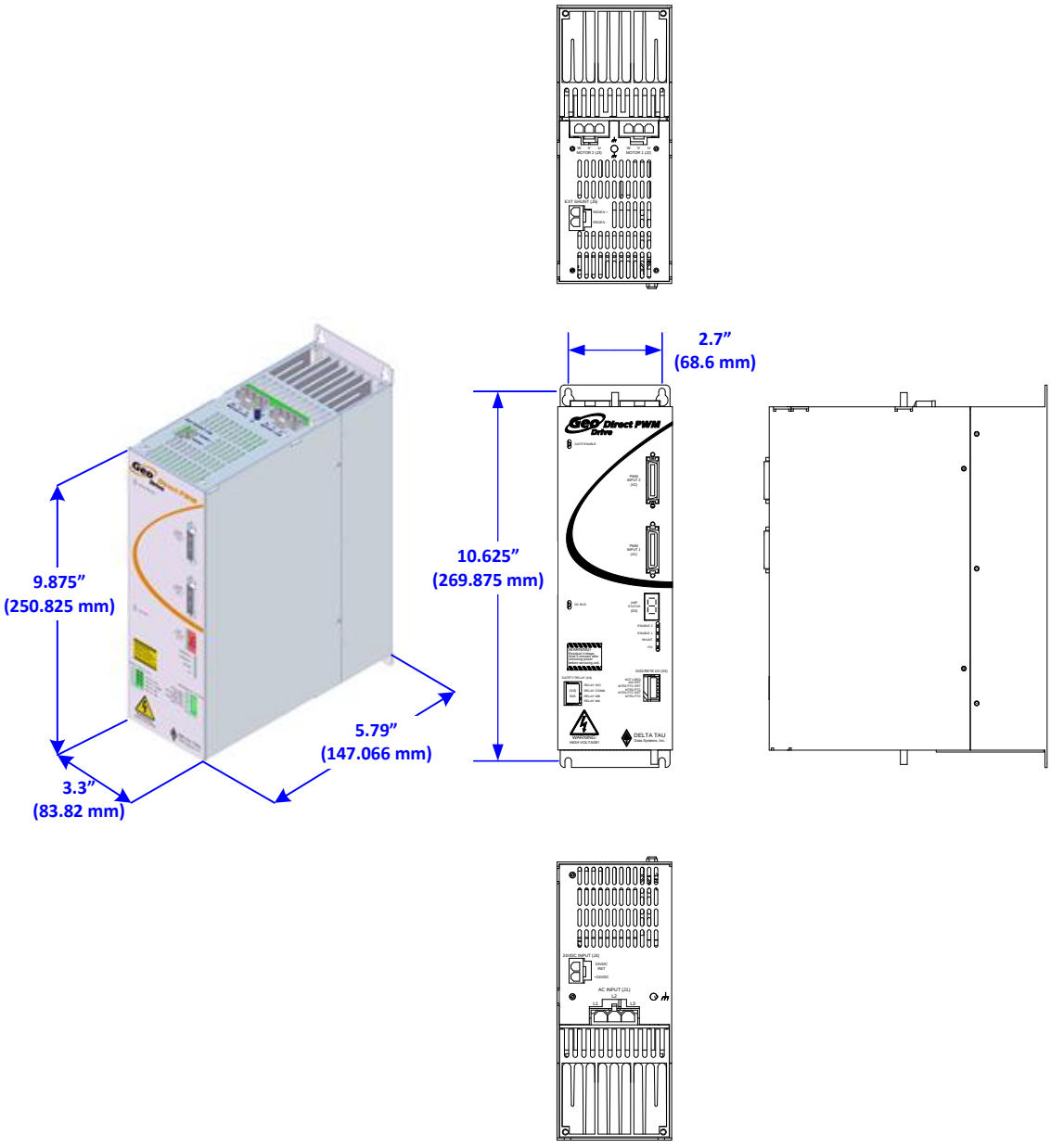
Low Profile, Single Width, No Fan



GPL032

Width	Height	Depth	Weight
3.30 in./ 84 mm	11.00 in./ 280 mm	8.00 in./ 203 mm	5.4 lbs/ 2.45 kgs

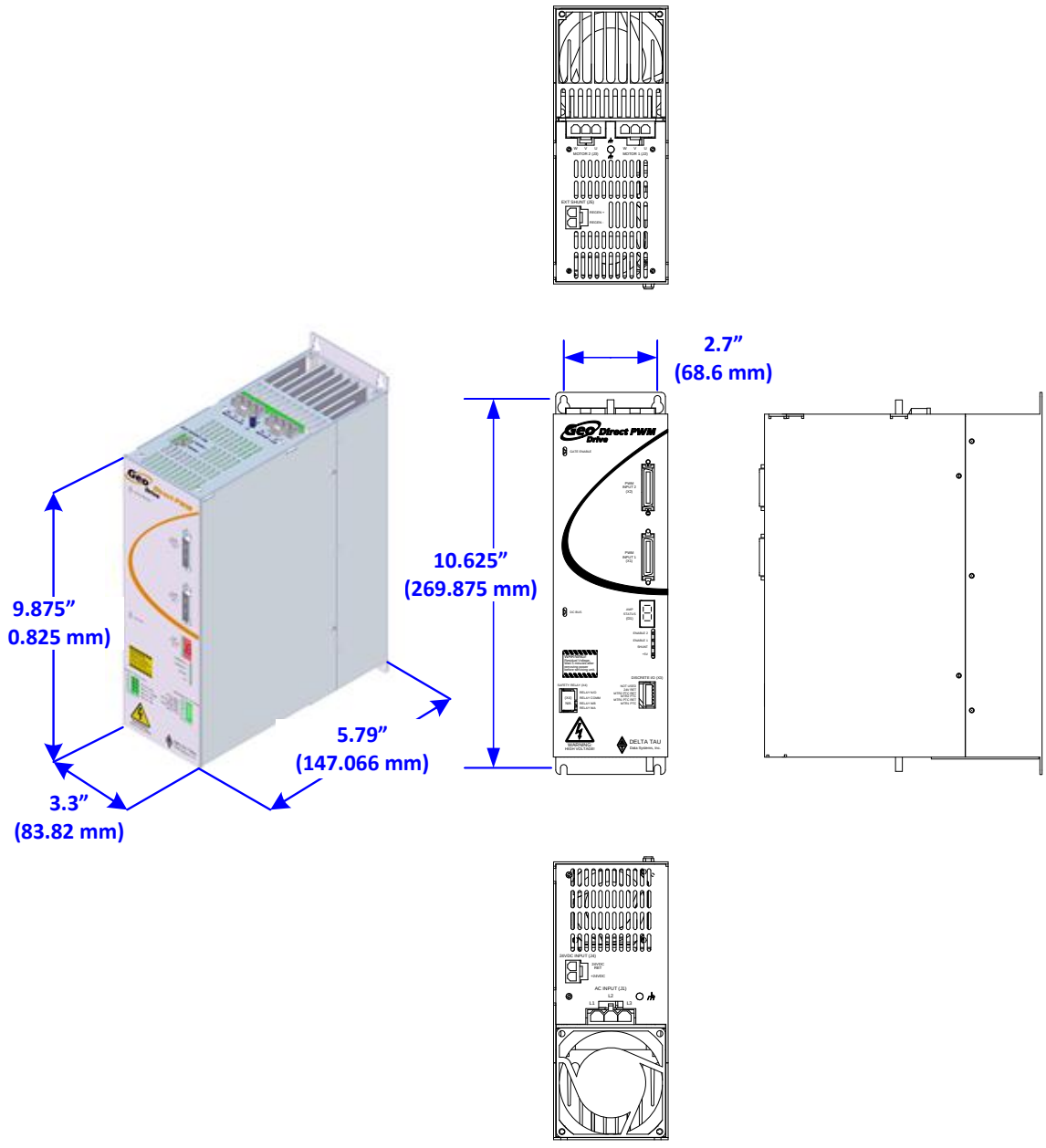
Single Width, No Fan



GPx05x, GPx102, GPL101, GPH032

Width	Height	Depth	Weight
3.30 in./ 84 mm	11.00 in./ 280 mm	8.00 in./ 203 mm	5.5 lbs/ 2.5 kgs

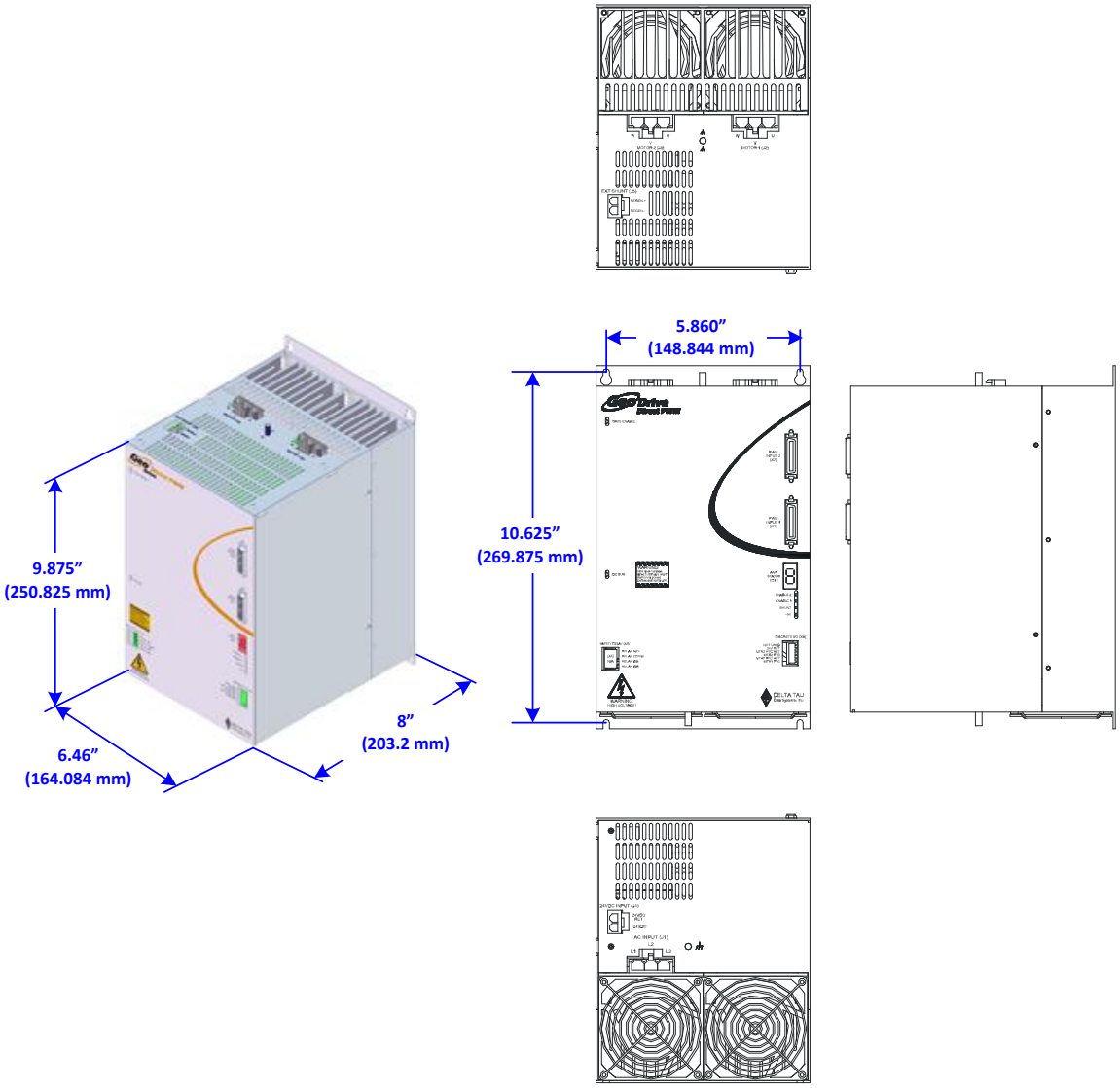
Single Width with Fan



GPx201, GPx301, GPx152, GPH102

Width	Height	Depth	Weight
6.50 in./ 165 mm	11.00 in./ 280 mm	8.00 in./ 203 mm	11.5 lbs/ 5.2 kgs

Double Width, Two Fans



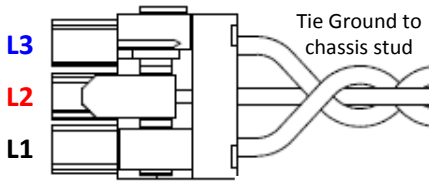
CONNECTOR PINOUTS AND WIRING

WARNING

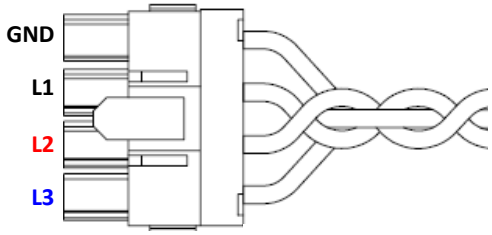
Installation of electrical control equipment is subject to many regulations including national, state, local, and industry guidelines and rules. General recommendations can be stated but it is important that the installation be carried out in accordance with all regulations pertaining to the installation.

J1: Main Bus Power Input

J1 is used to bring the main AC/DC bus power into the Geo Direct PWM Drive.

J1: Molex 3-pin Female **Mating: Molex 3-pin Male**					
Pin #	**Symbol**	**Function**	**Three Phase**	**Single Phase**	**DC**
1	L3	Input	AC Line Phase 3	Line	DC+
2	L2	Input	AC Line Phase 2	Neutral	DC Return
3	L1	Input	AC Line Phase 1	Not connected	Not connected
DT Housing pn: 014-H00F03-049 DT Pins pn: 014-042815-0031			Molex housing pn: 42816-0312 Molex pins pn: 42815-0031		

GPx201 and GPx301

J1: Molex 4-pin Female **Mating: Molex 4-pin Male**					
Pin #	**Symbol**	**Function**	**Three Phase**	**Single Phase**	**DC**
1	L3	Input	AC Line Phase 3	Line	DC+
2	L2	Input	AC Line Phase 2	Neutral	DC Return
3	L1	Input	AC Line Phase 1	Not connected	Not connected
4	GND	Common Ground			
DT Housing pn: 014-H00F04-049 DT Pins pn: 014-042815-0031			Molex housing pn: 42816-0412 Molex pins pn: 42815-0031		

Note

AC input wires must be twisted together to eliminate as much noise radiation as possible.

Recommended Main Bus Power Wiring/Protection

Caution

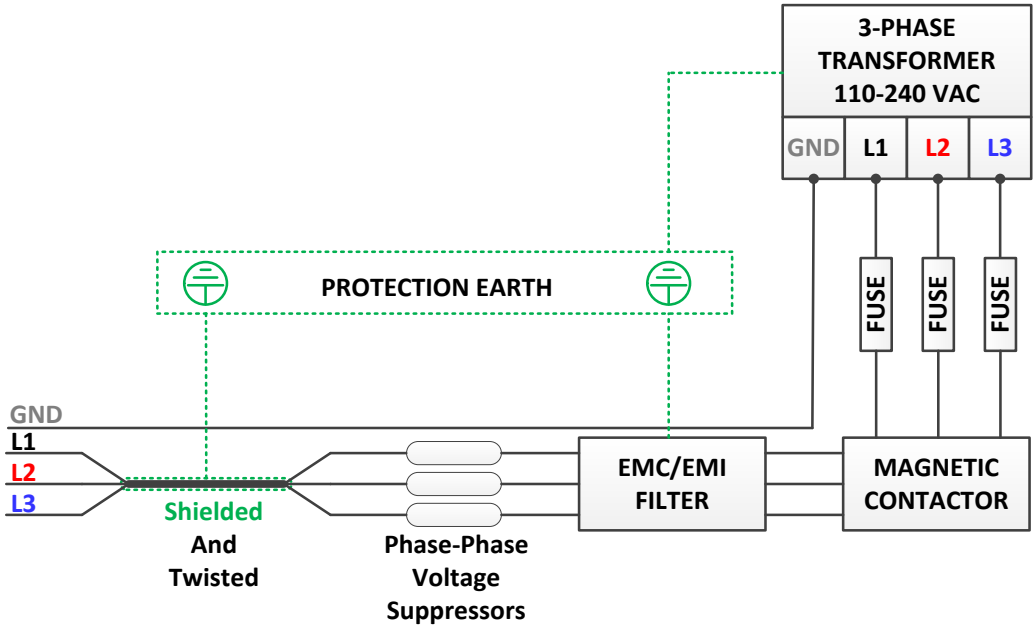
Main bus power lines should run in a separate duct (at least 12” or 30 cm away) from and should never be bundled with the I/O signal, communication, or encoder cables.

Grounding, Bonding

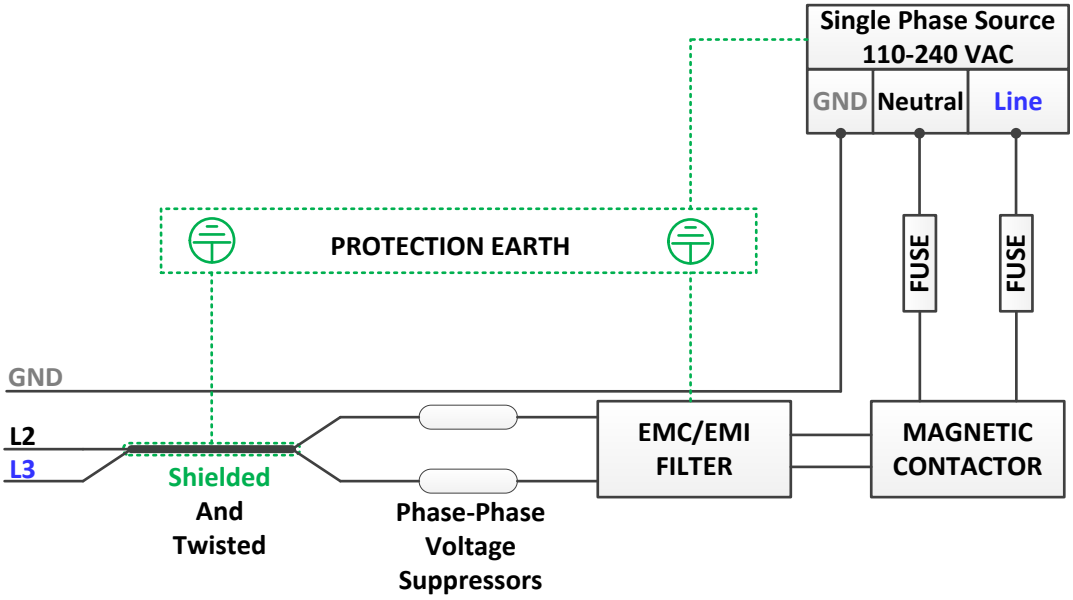
System grounding is crucial for proper performance of the Geo Direct PWM Drive. Panel wiring requires that a central earth-ground (also known as ground bus bar) location be installed at one part of the panel. The ground bus bar is usually a copper plate directly bonded to the back panel. This electrical ground connection allows for each device within the enclosure to have a separate wire brought back to the central earth-ground.

- Motor shields are best grounded at both ends of the cable. Motor cable shields should be bonded to the back panel using 360-degree clamps at the point they enter or exit the panel. Always use metal shells.
- Implement a star point ground connection scheme; so that each device wired to earth ground has its own conductor brought directly back to the central earth ground plate (bus bar).
- Use an unpainted back panel. This allows a wide area of contact for all metallic surfaces, reducing frequency impedances.
- Use a heavy gauge ground earth conductors made up of many strands of fine conducts.
- The Geo Direct PWM Drive is brought to the earth-ground via one or two wire(s) connected to the M4 mounting stud(s) through a heavy gauge multi-strand conductor to the central earth-ground.

Three-Phase Main AC Power Wiring Diagram



Single-Phase Main AC Power Wiring Diagram



Note

If the Geo Direct PWM Drive model does not have a ground pin on the bus input connector, then the transformer ground (GND) can be tied to the grounding stud or chassis ground.

Transformers

Y-Y or Y-Δ transformers should be used.

Δ-Δ Transformers are NOT advised. They try to balance phases dynamically, creating instances of instability in the Geo Direct PWM Drive's rectifying circuitry.

Note

A line reactor should be installed if a transformer or reliable source of power is not available. Line reactors suppress harmonics bi-directionally, eliminating low frequency spikes.

Fuses

High peak currents and high inrush currents demand the use of slow blow time delayed type fuses. RK1 or RK5 (i.e. current limiting) classes are recommended. **FRN-R** and **LPN-RK** from **Cooper Bussmann** or similar fuses can be used.

Magnetic Contactors

SC-E series from **Fuji Electric** or similar contactor can be used.

Line Filters

Line filters eliminate electromagnetic noise in a bi-directional manner (from and into the system). T type filters are NOT recommended. PI type line filters are highly advised:

- Filter should be mounted on the same panel as the drive and power source.
- Filter should be mounted as close as possible to the power source.
- Filter should be mounted as close as possible to incoming cabinet power.

FN-258 series from **Schaffner** or similar filter can be used.

Voltage Suppressors

Voltage suppressors eliminate undesirable voltage spikes typically generated by the magnetic contactor or external machinery in the plant.

This 3-phase **voltage arrester** from **Phoenix Contact** or similar suppressor can be used.

Recommended Bus Power Fuse and Wire Gauge

Geo Drive electronics create a DC bus by rectifying the incoming AC lines. The current flow into the drive is not sinusoidal but rather a series of narrow, high-peak pulses. Keep the incoming impedance small so that these current pulses are not hindered. Conductor size, transformer size, and fuse size recommendations may seem larger than normally expected.

Model	GPL012	GPL032 GPL051 GPL052 GPL101 GPL102	GPL151 GPL152 GPL201	GPL301	GPH012	GPH032 GPH051 GPH052 GPH101 GPH102	GPH151 GPH152 GPH201	GPH301
Fuse (FRN/LPN)	15	20	25	30	15	20	25	30
Wire Gauge	14	12	10	8	14	12	25	30

Note

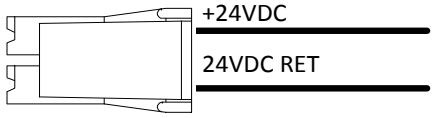
All ground conductors should be 8AWG minimum using wires constructed of many strands of small gauge wire. This ensures the lowest impedance to high-frequency noises.

J4: 24 VDC Logic Control

J4 is used to bring the 24VDC logic power into the Geo Direct PWM Drive. This power can remain on, regardless of the main AC/DC bus power input, allowing the digital control electronics to be active while the main motor power control is passive.

It is recommended to use a protected power supply. In situations where the power supply is shared with other devices, it may be desirable to insert a filter before applying it to the Geo Direct PWM Drive.

If multiple drives are driven out of the same 24VDC power supply, it is recommended that each Geo Direct PWM Drive be wired back to the power supply terminals independently. It is also recommended that the power supply be sized to handle the instantaneous inrush current required to start up the DC-to-DC converter action inside the Drive(s). See electrical specifications.

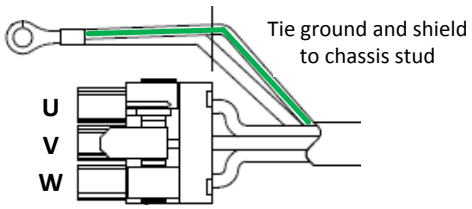
J4: Molex 2-pin Female **Mating: Molex 2-pin Male**				
Pin #	**Symbol**	**Function**	**Description**	**Notes**
1	24VDC RET	Common	Control power return	
2	+24VDC	Input	Control power input	24V+/-10%, @ 2A
DT Housing pn: 014-000F02-HSG DT Pins pn: 014-043375-001			Molex housing pn: 44441-2002 Molex pins pn: 43375-0001	

Note

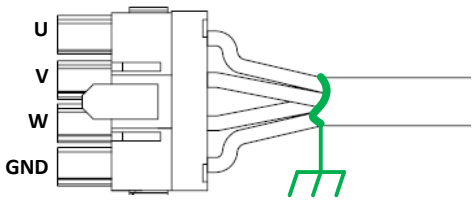
This connection can be made using 16 AWG wire.

J2 – J3: Motor Wiring

The cable wiring must be shielded and have a separate conductor connecting the motor frame back to the Geo Direct PWM Drive's chassis.

J2 – J3: Molex 3-Pin Female **Mating: Molex 3-Pin Male**		
Symbol	**Function**	**Description**
U	Motor Output	Axis 1 Phase 1
V	Motor Output	Axis 1 Phase 2
W	Motor Output	Axis 1 Phase 3
DT Housing pn: 014-H00F03-049 DT Pins pn: 014-042815-0031		Molex housing pn: 42816-0312 Molex pins pn: 42815-0031

GPx201, GPx301

J2 – J3: Molex 4-pin Female **Mating: Molex 4-pin Male**		
Symbol	**Function**	**Description**
U	Motor Output	Axis 1 Phase 1
V	Motor Output	Axis 1 Phase 2
W	Motor Output	Axis 1 Phase 3
GND	Ground	
DT Housing pn: 014-H00F04-049 DT Pins pn: 014-042815-0031		Molex housing pn: 42816-0412 Molex pins pn: 42815-0031

Note

The Geo Direct PWM Drive endorses the U, V, and W nomenclature for phases 1 through 3 respectively. Some motor manufacturers will call them A, B, and C. Others may call them L1, L2, and L3.

Note

For wiring DC brush motors, use phases U and W, and leave V floating.

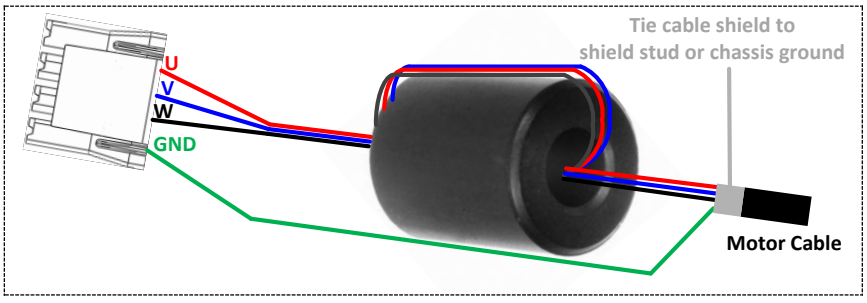
Note

The motor thermostats are brought in through connector X3.

Motor Cable, Noise Elimination

The Geo Direct PWM Drives' voltage output has a fundamental frequency and amplitude that corresponds to motor speed, torque, and number of poles. The Geo Direct PWM Drive produces higher frequency voltage components corresponding to the rise, fall and repetition rate of the fast switching PWM signals. Subsequently, it could naturally couple current noise to nearby conductors. This electrical coupling can be problematic, especially in noise-sensitive applications such as using high-resolution sinusoidal encoders, or high rate of communication which could suffer from Electro-Magnetic Interference EMI. Proper grounding, shielding, and filtering can alleviate most noise issues. Some applications may require additional measures such as PWM edge filters. The following; are general guidelines for proper motor cabling:

- Use a motor cable with **high quality shield**. A combination braid-and-foil is best.
- **The motor drain wires and cable shield should be tied together, and attached at both ends of the motor and Geo Direct PWM Drive chassis**. At the motor end, make a 360 degree connection between the shield and motor frame. If the motor has a metal shell connector, then you can tie the shield directly to the metal shell of the mating connector. The connection between the cable shield and the motor frame should be as short as possible). At the Geo Direct PWM Drive end, make a 360 degree connection between the shield and the provided studs or grounded chassis (protection earth) at the M4 mounting screws.
- The motor cable should have a **separate conductor (drain wire) tying the motor frame to the Geo Direct PWM drive**'s chassis.
- **Keep the motor cable as short as possible** to maintain lower capacitance (desirable). A capacitance of up to 50 PicoFarads per foot (0.3048 m), and runs of up to 200 feet (60 m) are acceptable with 240VAC. Exceeding these lengths requires the installation of a Snubber at the motor end or an in-series inductor at the Geo Direct PWM Drive end.
- If the grounding/shielding techniques are insufficient, you may **install chokes in the motor phases at the Geo Direct PWM Drive end** such as wrapping individual motor leads several times through a ferrite core ring. DigiKey, Micro-Metals (T400-26D), Fair Rite (2643540002), or equivalent ferrite cores are recommended. This adds high-frequency impedance to the outgoing motor cable thereby making it harder for high-frequency noise to leave the control area.



Note

Ferrite cores are also commonly used with lower inductance motors to enhance compatibility with the Geo Direct PWM Drive, which is specified to a minimum of 2 mH.

- **Do not use a motor wire gauge less than 14 AWG for 5/10A or 8/16A axes, and 10 AWG for 15/30A or 30/60A axes** unless otherwise specified by the motor manufacturer. Refer to Motor manufacturer and local code recommendations.

- Avoid running sensitive signal cables (i.e. encoders, small signal transducers) in the same cable bundle as the motor cable(s).

- Install dv/dt filter, Trans-coil V1K series (Optional).

Motor Selection

The Geo Direct PWM Drive interfaces with a wide variety of motors. It supports virtually any kind of three-phase AC/DC rotary, linear brushless, or induction motors. Using two out of the three phases, it is also possible to drive permanent magnet DC brush motors.

Motor Inductance

Digital direct PWM control requires a significant amount of motor inductance to drive the on-off voltage signals resulting smooth current flow with minimal ripple. Typically, servomotors' phase inductance ranges from 2 to 15mH. The lower the inductance, the higher is the suitable PWM frequency.
Low inductance motors (less than 2 mH) can see large ripple currents causing excessive energy waste and overheating. Additional in-series inductance is recommended in these cases.
High inductance motors (greater than 15 mH) are slower to react and generally not considered high performance servo motors.

Motor Resistance

Motor resistance is not typically a determining factor in the drive/system performance but rather comes into play when extracting a desired torque or horsepower out of the motor is a requirement.

Motor Inertia

Motor inertia is an important parameter in motor sizing. Considering the reflected load inertia back to the motor in this process is important. In general, the higher the motor inertia, the more stable the system will inherently be. A high ratio of load to motor inertia shrinks the operating bandwidth (gain limited) of the system, especially in applications using belt or rubber based couplings. The ratio of load to motor inertia is typically around 3:1. Mechanical gearing is often used to reduce reflected inertial load going back to the shaft of the motor.

Motor Speed

In some applications, it is realistically impossible to achieve the motors' specified maximum velocity. Fundamentally, providing sufficient voltage and proper current-loop tuning should allow attaining motor maximum speeds. Consider feedback devices being a limitation in some cases, as well as the load attached to the motor. In general, the maximum speed can be determined dividing the line-to-line input voltage by the back EMF constant Kb of the motor. Input voltage headroom of about 20% is recommended for good servo control at maximum speed.

Motor Torque

Torque requirements in an application can be viewed as both instantaneous and average
Typically, the instantaneous or peak torque is the sum of machining, and frictional forces required to accelerate the inertial load. The energy required to accelerate a load follows the equation T=JA where T is the torque, J is the inertia, and A is the acceleration. The required instantaneous torque is then divided by the motor torque constant (Kt) to determine the necessary peak current of the Geo Direct PWM Drive. Headroom of about 10% is always desirable to account for miscellaneous losses (aging, wear and tear, calculation roundups).
The continuous torque rating of the motor is bound by thermal limitation. If the motor applies more torque than the specified threshold, it will overheat. Typically, the continuous torque ceiling is the RMS current rating of the motor, also known as torque output per ampere of input current.

Required Bus Voltage for Speed and Torque

For a required motor Speed, and continuous Torque, the minimum DC Bus Voltage (V_{DC}) can be estimated by looking at the equivalent single phase circuit:

The vector sum of back EMF, voltage across resistor and inductor should be less than $V_{DC}/\sqrt{6}$.

For a Rotary Motor:

$$\sqrt{V_L{}^2+\left(V_R+V_{BEMF}\right)^2}=\sqrt{\left(\frac{R_{RPM}}{60}\cdot N_p\cdot 2\cdot\pi\cdot L_p\cdot\frac{T_M}{K_t}\right)^2+\left(\frac{T_M}{K_t}R_p+\frac{R_{RPM}}{60}\cdot\frac{K_t}{3}\cdot 2\cdot\pi\right)^2}\le M_{derate}\frac{V_{DC}}{\sqrt{6}}$$

Where:

V_L	: Voltage Across equivalent inductor	L_P	: Phase Inductance [H]
V_R	: Voltage Across equivalent resistor	R_P	: Phase Resistance [Ω]
V_{BEMF}	: Back electromotive force voltage	T_M	: Required Continuous Torque [N.M]
R_{RPM}	: Required Motor Speed [rpm]	K_T	: Motor Torque Constant RMS [N.M/A]
N_P	: Number of pole pairs	M_{derate}	: De-rate parameter (typically 0.8)

For a Linear Motor:

$$\sqrt{V_L{}^2+\left(V_R+V_{BEMF}\right)^2}=\sqrt{\left(\frac{V_{motor}}{D_{pitch}}\cdot L_p\cdot\frac{F_M}{K_t}\right)^2+\left(\frac{F_M}{K_t}R_p+\frac{V_{motor}}{D_{pitch}}\cdot\frac{K_t}{3}\right)^2}\le M_{derate}\frac{V_{DC}}{\sqrt{6}}$$

Where:

V_L	: Voltage across equivalent inductor	L_P	: Phase Inductance [H]
V_R	: Voltage across equivalent resistor	R_P	: Phase Resistance [Ω]
V_{BEMF}	: Back electromotive Force voltage	F_M	: Required Motor Force RMS [N]
V_{motor}	: Required Motor Speed [m/s]	K_t	: Motor Force Constant RMS [N/A]
M_{derate}	: De-rate parameter (typically 0.8)	D_{Pitch}	: Magnetic Pitch [m]

Example:
An application requires running a motor at 500 RPM with a continuous torque of 30 N.M. The motor specs are as follow:

$L_p = 10\text{mH},\ R_p = 2\text{Ohm},\ N_p = 16,\ K_t = 2.187\text{Nm/Amps}$

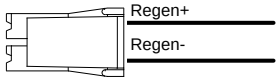
Using the equation above, a minimum bus of 233 VDC (~165VAC) is necessary to achieve the speed and torque requirements.

J5: External Shunt Resistor

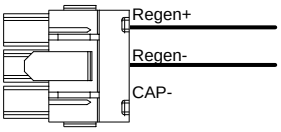
J5 is used to wire an external shunt resistor to expel the excess power during demanding deceleration profiles. These shunt resistors are designed to drain excess bus energy very quickly.

Caution

All applications using Geo direct PWM Drives (all configurations) are strongly advised to install an external shunt resistor.

J5: Molex 2-Pin Female **Mating: Molex 2-Pin Male**			
Pin #	**Symbol**	**Function**	
1	REGEN-	Output	
2	REGEN+	Output	
Molex Mating Connector p/n: 0444412002 Molex Crimper tool p/n: 63811-0400 Molex Pins p/n: 0433751001 Delta Tau Mating Connector p/n: 014-000F02-HSG Delta Tau Pins p/n: 014-043375-001			

Gxx201, Gxx301

J5: Molex 3-Pin Female **Mating: Molex 3-Pin Male**			
1	CAP-	Bus – (do NOT wire)	
2	REGEN-	Output	
3	REGEN+	Output	
Molex Mating Connector p/n: 0428160312 Molex Crimper tool p/n: 63811-1500 Molex Pins p/n: 0433751001 Delta Tau Mating Connector p/n: 014-H00F03-049 Delta Tau Pins p/n: 014-042815-001			

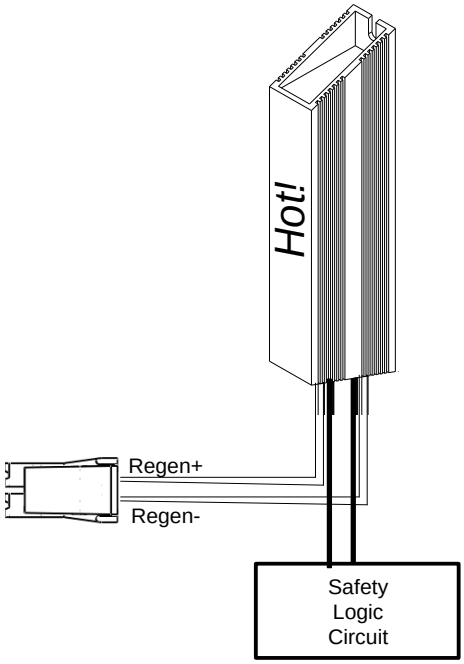
Caution

The external shunt resistors can reach temperatures of up to 200°C. They must be mounted away from other devices and ideally near the top of the cabinet, also ensure they are enclosed and cannot be touched during operation or anytime they are hot. Sufficient warning labels should be placed prominently nearby.

The black wires are for the thermostat and the white wires are for the shunt resistor.

The shunt resistor incorporates a normally closed (N.C) thermal overload protection thermostat that opens up when the core temperature of the resistor exceeds 225°C (450° F). This thermostat is accessible through the two black leads. It is important that these two leads be wired in a safety circuit to halt operation should the resistor temperature exceed the specified threshold.

The external shunt resistor Ohm rating range is found so that the minimum value limits the current to the permissible amperage, and that the maximum value limits the bus (during deceleration) to the permissible voltage.



Note

For GPL models, the shunt circuitry turn-on threshold is 392 VDC (~278 VAC). The turn-off threshold is 372 VDC (~263VAC).

Note

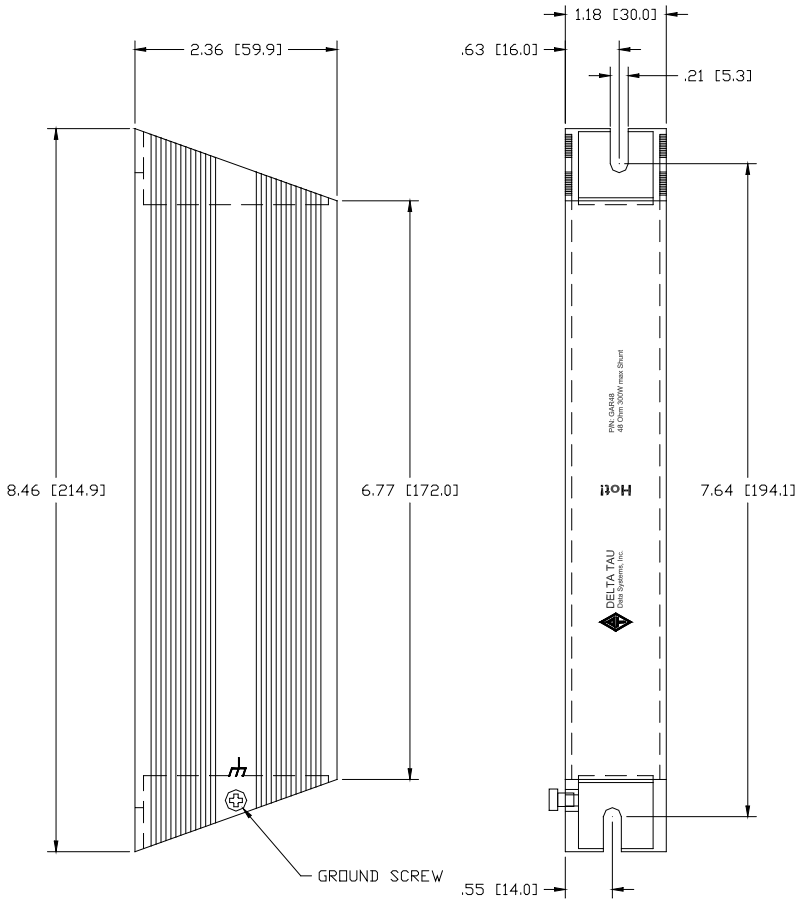
For GPH models, the shunt circuitry turn-on threshold is 784 VDC (~555 VAC). The turn-off threshold is 744 VDC (~526VAC).

Recommended Shunt Resistors

Model	Ω	W	Peak Power(W)	Pins	Shunt Resistor
GPL011	48	150	3,134	2	GAR48
GPL031	48	150	3,134	2	GAR48
GPL051	22	300	6,839	2	GAR22
GPL101	22	300	6,839	2	GAR22
GPL151	10	300	15,045	2	GAR10-2
GPL201	10	300	15,045	3	GAR10-3
GPL301	10	300	15,045	3	GAR10-3
GPL012	48	150	3,134	2	GAR48
GPL032	48	150	3,134	2	GAR48
GPL052	22	300	6,839	2	GAR22
GPL102	22	300	6,839	2	GAR22
GPL152	10	300	15,045	2	GAR10-2

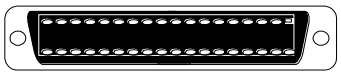
Model	Ω	W	Peak Power(W)	Pins	Shunt Resistor
GPH011	78	150	7,971	2	GAR78
GPH031	78	150	7,971	2	GAR78
GPH051	78	150	7,971	2	GAR78
GPH101	48	300	12,455	2	GAR48
GPH151	22	300	27,175	2	GAR22
GPH201	15	300	39,856	3	GAR15-3
GPH301	15	300	39,856	3	GAR15-3
GPH012	78	150	7,971	2	GAR78
GPH032	78	150	7,971	2	GAR78
GPH052	48	150	12,455	2	GAR48
GPH102	48	150	12,455	2	GAR48
GPH152	22	300	27,175	2	GAR22

Shunt Resistor Layout



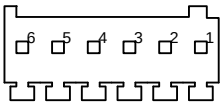
X1 – X2: PWM Connectors

This mini D36 connector provides the interface to the PWM output channel from the controller (PMAC).

X1 – X2: 36-Pin Mini-D Connector				
Pin#	**Symbol**	**Function**	**Description**	**Notes**
1	Reserved			
2	Reserved			
3	ADC_CLK1+	Command	A/D converter clock	
4	ADC_STB1+	Command	A/D converter strobe	
5	CURRENT1A+	Feedback	Phase A actual current data	Serial digital
6	CURRENT1B+	Feedback	Phase B actual current data	Serial digital
7	AENA1+	Command	Amplifier enable	High is enable
8	FAULT1+	Feedback	Amplifier fault	High is fault
9	PWMATOP1+	Command	Phase A top cmd	High is on command
10	PWMABOT1+	Command	Phase A bottom cmd	High is on command
11	PWMBTOP1+	Command	Phase B top cmd	High is on command
12	PWMBBOT1+	Command	Phase B bottom cmd	High is on command
13	PWMCTOP1+	Command	Phase C top cmd	High is on command
14	PWMCBOT1+	Command	Phase C bottom cmd	High is on command
15	GND	Common	Reference voltage	
16	+5V	Power	+5V Power	From controller
17	Reserved			
18	Reserved			
19	Reserved			
20	Reserved			
21	ADC_CLK1-	Command	A/D converter clock	
22	ADC_STB1-	Command	A/D converter strobe	
23	CURRENT1A-	Feedback	Phase A actual current DATA	Serial digital
24	CURRENT1B-	Feedback	Phase B actual current DATA	Serial digital
25	AENA1-	Command	Amplifier enable	Low is enable
26	FAULT1-	Feedback	Amplifier fault	Low is fault
27	PWMATOP1-	Command	Phase A top cmd	Low is on command
28	PWMABOT1-	Command	Phase A bottom cmd	Low is on command
29	PWMBTOP1-	Command	Phase B top cmd	Low is on command
30	PWMBBOT1-	Command	Phase B bottom cmd	Low is on command
31	PWMCTOP1-	Command	Phase C top cmd	Low is on command
32	PWMCBOT1-	Command	Phase C bottom cmd	Low is on command
33	GND	Common	Reference Voltage	
34	+5V	Power	+5V Power	From controller
35	Reserved			
36	Reserved			

X3: Discrete I/O for Motor Thermals

This 6-pin Phoenix Contact terminal block provides connectivity to low impedance 12 – 24 VDC motor thermostat overload detection. This is a normally closed contact, in normal mode operation the Geo direct PWM Drive expects to see 12 – 24 VDC coming into Pins #1 and #3 respectively for motors 1 and 2.

X3: Phoenix 6-Pin TB Female **Mating: Phoenix 6-pin TB Male**			
Pin #	**Symbol**	**Function**	**Description**
1	MTR1 PTC	Input	Motor 1 thermal
2	MTR 1 PTC RTN	Return	
3	MTR2 PTC	Input	Motor 2 thermal
4	MTR2 PTC RTN	Return	
5	24V RET	Common	
6	N.C.	Not Connected	
Part Type: FKMC 0,5/6-ST-2,5 Phoenix Contact p/n: 1881367			

Note

If nothing is wired fault codes **5** and **A** are triggered respectively for motors 1 and 2. Tie MTR PTC and MTR PTC RET to disable this function.

Note

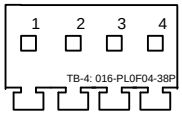
These contacts can be used for other general purpose safety functions to kill motor power when desired.

X4: Safety Relay

This 4-pin Phoenix Contact Terminal Block provides connectivity to a safety relay input, and

If the Safety Relay option is installed, there is a dedicated Safety Input @24VDC (user supplied). When the Safety Input is asserted, then the hardware will cut the 20V power to the gate driver which will prevent all output from the power stage (the Gate Enable LED will turn off).

If the user doesn't need to use the Safety Input and the drive has it installed, the user has to bypass it by wiring a 24VDC input to WA (pin 1) and the return (24VDC) to WB (pin 2).

X4: Phoenix Contact 4-Pin TB Female Mating: Phoenix Contact 4-Pin TB Male			
Pin #	**Symbol**	**Function**	**Description**
1	RELAY WA	Input	Safety Input 24V
2	RELAY WB	Input	Safety Input Return
3	RELAY COM	Common	
4	RELAY N/O	Relay	Normally Open

Note

There are no software configurable parameters to enable/disable or otherwise manipulate the Safety Input functionality.

POWER ON/OFF PROCEDURES

Caution

Changing the ADC clock on the controller (PMAC) side requires recycling power on the Geo Direct PWM Drive.

Caution

Main bus power should NEVER be applied if the 24V logic power is NOT applied.

Caution

Make sure that no motor commands (e.g. phasing, jogging, or open loop) are being executed by or sent by the controller (PMAC) at the time of applying main bus power.

- **Powering up** the Geo Direct PWM Drive must obey the following procedure:

1. Make sure that PMAC is powered up, and that the PWM cable is connected
2. Apply 24V logic power to the Geo Direct PWM Drive
3. Wait a minimum of ~3 seconds
4. Apply main bus power
5. Wait ~ 3seconds before enabling the drive (motor)

- **Powering down** the Geo Direct PWM Drive must obey the following procedure:

1. Disconnect main bus power
2. Wait a minimum of ~5 seconds
3. Disconnect 24V logic power

Cycling Main Bus Power

Caution

Main bus power should NEVER be applied or cycled if the 24V logic power is NOT applied.

Cycling main bus power must obey the following warning restrictions. A delay should be inserted in either software, hardware or both to ensure that these restrictions are conformed.

Caution

Do NOT to cycle main bus power frequently and rapidly within a few seconds.

If the main bus power is removed (i.e. E-Stop condition), it is necessary to keep it off until the Bus LED is turned off or dimmed completely. About 5-6 minutes. This ensures that the capacitors' voltage has dropped below 97 VAC and that the soft start circuitry has been armed.

Caution

Main bus power should Not be recycled within a time range of about ~ **5 minutes.**

Note

With the GPx201 and GPx301 models, it is possible to use the external shunt resistor as a bleeding resistor to avoid the downtime delay. Contact Delta Tau for details.

PWM FREQUENCY

The minimum PWM frequency of a system is based on the time constant of the motor. In general, the lower the time constant, the higher the PWM frequency should be. The motor time constant is calculated dividing the motor inductance by the resistance (phase-phase). The minimum PWM Frequency is then determined using the following relationship:

$$\tau_{sec} = \frac{L_H}{R_\Omega} \quad ; \quad \tau_{sec} > \frac{20}{2 \times \Pi \times f_{PWM}}$$

$$\Rightarrow \boxed{f_{PWM}(Hz) > \frac{20 \times R_\Omega}{2 \times \Pi \times L_H}}$$

Example: A motor with an inductance of 6.1 millihenries (mH), and a resistance of 11.50 Ohms (Ω phase-phase) yields a time constant of 0.53 milliseconds. Therefore, the minimum PWM Frequency is about ~6000Hz (6.0 KHz).

Note

Systems with very low time constants (needing higher PWM frequencies) may require the addition of chokes or in-line inductive loads to obtain a good current loop bandwidth.

Note

The maximum PWM frequency for each model of the Geo Direct PWM Drives is listed in the electrical specifications.

POWER PMAC3 DRIVE SETUP

Caution

The ADC Strobe Word, **Gate3[i].AdcAmpStrobe**, must be set to **$FFFFFC** for proper operation in default mode. Failure to do so could result in damage to the amplifier.

Key Gate Parameters

The following Gate-specific parameters are essential for the proper software setup of the Geo Direct PWM Drive:

Structure Element	Description	Typical/Default	Notes
Sys.WpKey	PMAC3 Write Protection	0	$AAAAAAAA to allow writing
Gate3[i].PhaseFreq	Phase Frequency	9000	9.00 KHz Phase
Gate3[i].ServoClockDiv	Servo clock divider	3	2.25 KHz Servo
Gate3[i].HardwareClockCtrl	Hardware Clocks	$55555403	2.50 MHz ADC Clock
Sys.ServoPeriod	=1000*(Gate3[i].ServoClockDiv+1)/Gate3[i].PhaseFreq		
Sys.PhaseOverServoPeriod	= 1 /(Gate3[i].ServoClockDiv + 1)		
Gate3[i].AdcAmpStrobe	ADC Strobe Word	**$FFFFFC**	Default Mode
Gate3[i].Chan[j].OutputMode	Output mode	**0**	PWM output

Note

Sys.ServoPeriod and Sys.PhaseOverServoPeriod must be re-computed if the main clocks (Phase, and Servo) are changed.

Note

The above settings require a **Save** and a Reset (**$$$**) on the PMAC side in order to take effect.

Key Channel Parameters

The following channel-specific parameters are essential for the proper software setup of the Geo Direct PWM Drive:

Structure Element	Description	Typical/Default	Notes
Gate3[i].Chan[j].PwmFreqMult	PWM Frequency	0	4.5 KHz PWM
Motor[x].ServoCtrl	Activate channel	1	
Motor[x].PhaseCtrl	Commutation enable	1	With PackInData = 0
Motor[x].PhaseOffset	Commutation Phase angle	**-683**	**-512** for Brush Motor
Motor[x].pAdc	Current Feedback Address	Pointer	Initiated by the firmware
Motor[x].AdcMask	ADC Mask	**$FFF00000**	
Motor[x].PwmSf	PWM Scale Factor	= 0.9 * 16384	Voltage limiter
Motor[x].I2TSet	Continuous current limit	To be Computed	Motor I^2T protection
Motor[x].I2TTrip	Integrated current limit		Motor I^2T protection
Motor[x].MaxDac	Maximum command output		Current limiter
Motor[x].IiGain	Integral	Current Loop Tuning	
Motor[x].IpfGain	Forward path proportional		
Motor[x].IpbGain	Back-path proportional		

Note

A **Save** and a Reset (**$$$**) is necessary for these parameters to take effect.

- Motor[x].PwmSf is calculated based on the motor and bus voltages

  If the Motor Rated Voltage is greater than > Bus Voltage:
  Motor[x].PwmSf = 0.9 * 16384

  If the Motor Rated Voltage is less than < Bus Voltage:
  Motor[x].PwmSf = 0.9 * 16384 * V_{Motor}/V_{Bus}

- I2T Settings **Example:**

```
GLOBAL  ContCurrent = 3;       // RMS Continuous Current Limit [Amps] -User Input
GLOBAL  PeakCurrent = 9;       // RMS Instantaneous Current Limit [Amps] -User Input
GLOBAL  MaxADC = 16.26;        // =16.26 for 5/10A  -User Input, see electrical specs
GLOBAL  I2TOnTime = 2;         // Time allowed at peak Current [sec] -User Input

Motor[1].MaxDac = (PeakCurrent / MaxADC) * 32767 * COSD(30)
Motor[1].I2tSet = (ContCurrent / MaxADC) * 32767 * COSD(30)
Motor[1].I2tTrip = (POW(Motor[1].MaxDac,2) - POW(Motor[1].I2tSet,2)) * I2TOnTime
```

Caution

Trying to enable the Geo Direct PAM Drive with misreported current data could result in damaging the electronics of the Drive.

At this point of the drive-motor setup, and before tuning the current loop, a couple of sanity checks can be performed, making sure that:

- Enabling the drive with a #nOut0 command does not produce any faults in neither the drive nor the PMAC.
- The current sensors are operating properly by monitoring the current measurements (i.e. Motor[x].IaMeas, and Motor[x].IbMeas). These should be reporting values fluctuating around 0. Frozen values, or values greater than 1000 indicate that the current sensors are not functioning properly, or a software parameter is incorrect (i.e. Gate3[i].AdcAmpStrobe, Motor[x].PhaseOffset, Motor[x].AdcMask)

Subsequently, the current loop (Motor[x].IiGain, Motor[x].IpfGain, and Motor[x].IpbGain) can be tuned using the tuning utility in the IDE software. Commutation, encoder feedback, phasing, and position loop tuning can then be configured for closed loop control.

Note

Complete closed loop setup procedure can be found in the pertaining hardware axis-interface, and Power PMAC User/Software Reference manuals.

POWER PMAC2 DRIVE SETUP

Caution

The ADC Strobe Word, **Gate1[i].AdcStrobe**, must be set to $3FFFFF for proper operation in default mode. Failure to do so could result in damage to the amplifier.

Key Gate Parameters

The following Gate-specific parameters are essential for the proper software setup of the Geo Direct PWM Drive:

Structure Element	Description	Typical/Default	Notes
Gate1[i].PwmPeriod	PWM Frequency	6527	4.50 KHz PWM
Gate1[i].PhaseClockDiv	Phase clock divider	0	9.00 KHz Phase
Gate1[i].ServoClockDiv	Servo clock divider	3	2.25 KHz Servo
Gate1[i].HardwareClockCtrl	Hardware Clocks	2258	2.50 MHz ADC Clock
Sys.ServoPeriod	= 1000 * (Gate1[4].ServoClockDiv + 1) / 18000		
Sys.PhaseOverServoPeriod	= 1 / (Gate1[4].ServoClockDiv + 1)		
Gate1[i].AdcStrobe	ADC Strobe Word	**$3FFFFF**	Default Mode
Gate1[i].Chan[j].OutputMode	Output mode	**0**	PWM output

Note

Sys.ServoPeriod and Sys.PhaseOverServoPeriod must be re-computed if the main clocks (Phase, PWM, and Servo) are changed.

Note

The above settings require a **Save** and a Reset (**$$$**) on the PMAC side in order to take effect.

Key Channel Parameters

The following channel-specific parameters are essential for the proper software setup of the Geo Direct PWM Drive:

Structure Element	Description	Typical/Default	Notes
Motor[x].ServoCtrl	Activate channel	1	
Motor[x].PhaseCtrl	Commutation enable	1	
Motor[x].PhaseOffset	Commutation Phase angle	**683**	**512** for Brush Motor
Motor[x].pAdc	Current Feedback Address	Pointer	Initiated by the firmware
Motor[x].AdcMask	ADC Mask	**$FFF000**	
Motor[x].PwmSf	PWM Scale Factor	= 0.9 * Gate1[i].PwmPeriod	Voltage limiter
Motor[x].I2TSet	Continuous current limit	To be computed	Motor I^2T protection
Motor[x].I2TTrip	Integrated current limit		Motor I^2T protection
Motor[x].MaxDac	Maximum command output		Current limiter
Motor[x].IiGain	Integral gain	Current Loop Tuning	
Motor[x].IpfGain	Forward path proportional gain		
Motor[x].IpbGain	Back-path proportional gain		

Note

A **Save** and a Reset (**$$$**) is necessary for these parameters to take effect.

- Motor[x].PwmSf is calculated based on the motor and bus voltages

  If the Motor Rated Voltage is greater than > Bus Voltage:
  Motor[x].PwmSf = 0.9 * Gate1[i].PwmPeriod

  If the Motor Rated Voltage is less than < Bus Voltage:
  Motor[x].PwmSf = 0.9 * Gate1[i].PwmPeriod * V_{Motor}/V_{Bus}

- I2T Settings **Example:**

```
GLOBAL  ContCurrent = 3;        // RMS Continuous Current Limit [Amps] -User Input
GLOBAL  PeakCurrent = 9;        // RMS Instantaneous Current Limit [Amps] -User Input
GLOBAL  MaxADC = 16.26;         // = 16.26 for 5/10A  -User Input, see electrical specs
GLOBAL  I2TOnTime = 2;          // Time allowed at peak Current [sec] -User Input

Motor[1].MaxDac = (PeakCurrent / MaxADC) * 32767 * COSD(30)
Motor[1].I2tSet = (ContCurrent / MaxADC) * 32767 * COSD(30)
Motor[1].I2tTrip = (POW(Motor[1].MaxDac,2) - POW(Motor[1].I2tSet,2)) * I2TOnTime
```

Caution

Trying to enable the Geo Direct PAM Drive with misreported current data could result in damaging the electronics of the Drive.

At this point of the drive-motor setup, and before tuning the current loop, a couple of sanity checks can be performed, making sure that:

- Enabling the drive with a #nOut0 command does not produce any faults in neither the drive nor the PMAC.
- The current sensors are operating properly by monitoring the current measurements (i.e. Motor[x].IaMeas, and Motor[x].IbMeas). These should be reporting values fluctuating around 0. Frozen values, or values greater than 1000 indicate that the current sensors are not functioning properly, or a software parameter is incorrect (i.e. Gate1[i].AdcStrobe, Motor[x].PhaseOffset, Motor[x].AdcMask)

Subsequently, the current loop (Motor[x].IiGain, Motor[x].IpfGain, and Motor[x].IpbGain) can be tuned using the tuning utility in the IDE software. Commutation, encoder feedback, phasing, and position loop tuning can then be setup for closed loop control.

Note

Complete closed loop setup procedure can be found in the pertaining hardware axis-interface, and Power PMAC User/Software Reference manuals.

TURBO PMAC2 DRIVE SETUP

Caution

The ADC Strobe Word, I7m06 ($C014 in Non-Turbo PMAC), must be set to $3FFFFF for proper operation in default mode. Failure to set I7m06 equal to $3FFFFF could result in damage to the amplifier.

Key Gate Parameters

The following Gate-specific parameters are essential for the proper software setup of the Geo Direct PWM Drive:

Turbo	Non-Turbo	Description	Typical/Default	Notes
I7m00	I900	Max phase clock	6527	4.50 KHz PWM
I7m01	I901	Phase clock divider	0	9.00 KHz Phase
I7m02	I902	Servo clock divider	3	2.25 KHz Servo
I7m03	I903	Hardware Clocks	2258	2.50 MHz ADC Clock
I10	I10	Servo interrupt time	3713991	
I7m06	X:$C014	ADC Strobe Word	**$3FFFFF**	Default Mode
I7mn6	I9n6	Output mode	**0**	PWM output

Note

Non-Turbo ADC Strobe words are at addresses X:$C0**1**4 for axis 1-4 (1st PMAC2 Gate), and X:$C0**2**4 for axis 5-8 (2nd PMAC2 Gate).

Note

The servo interrupt time I10 must be re-computed if the main clocks (Phase, PWM, and Servo) are changed.

Note

The above settings require a **Save** and a Reset (**$$$**) on the PMAC side in order to take effect.

Key Channel Parameters

The following channel-specific parameters are essential for the proper software setup of the Geo Direct PWM Drive:

Variable	Description	Typical/Default	Notes
Ixx00	Activate channel	1	
Ixx01	Commutation enable	1	
Ixx72	Commutation Phase angle	**683**	**512** for Brush Motor
Ixx82	Current Feedback Address	Address Location	Found in the SRM Manual
Ixx84	ADC Mask	**$FFF000**	
Ixx66	PWM Scale Factor	= 0.9 * I7m00	Voltage limiter
Ixx57	Continuous current limit	To be computed	Motor I^2T protection
Ixx58	Integrated current limit		Motor I^2T protection
Ixx69	Maximum command output		Current limiter
Ixx61	Integral gain	Current Loop Tuning	
Ixx62	Forward path proportional gain		
Ixx76	Back-path proportional gain		

Note

A **Save** and a Reset (**$$$**) is necessary for these parameters to take effect.

- Ixx82 Turbo PMAC2 UMAC addresses (first 8 channels)

Channel 1	$078206	Channel 5	$078306
Channel 2	$07820E	Channel 6	$07830E
Channel 3	$078216	Channel 7	$078316
Channel 4	$07821E	Channel 8	$07831E

- Ixx66 is calculated based on the motor and bus voltages
  If the Motor Rated Voltage is greater than > Bus Voltage: Ixx66 = 0.9 * I7000
  If the Motor Rated Voltage is less than < Bus Voltage: Ixx66 = 0.9 * I7000 * V_{Motor}/V_{Bus}

- I2T Settings, Ixx57, Ixx58, and Ixx69 **Example:**

```
#define ServoClk        2.258   ; Servo Clock [KHz]—computed in Dominant Clock Settings Section
#define ContCurrent     3       ; Continuous Current Limit [Amps] -User Input
#define PeakCurrent     9       ; Instantaneous Current Limit [Amps] -User Input
#define MaxADC          16.26   ; =16.26 for 5/10A  -User Input, see electrical specs
#define I2TOnTime       2       ; Time allowed at peak Current [sec] -User Input

I157 = INT(32767*(ContCurrent*1.414/MaxADC)*cos(30))
I169 = INT(32767*(PeakCurrent*1.414/MaxADC)*cos(30))
I158 = INT((I169*I169- I157*I157)*ServoClk*1000*I2TOnTime/(32767*32767))
```

Caution

Trying to enable the Geo Direct PAM Drive with misreported current data could result in damaging the electronics of the Drive.

At this point of the drive-motor setup, and before tuning the current loop, a couple of sanity checks can be performed, making sure that:

- Enabling the drive with a #nO0 command does not produce any faults in neither the drive nor PMAC.
- The current sensors are operating properly by monitoring the current measurements (i.e. Mxx05, and Mxx06). These should be reporting value fluctuating around 0. Frozen values, or values greater than 1000 indicate that the current sensors are not functioning properly, or a software parameter is incorrect (i.e. I7m06, Ixx72, Ixx84)

Subsequently, the current loop (Ixx61, Ixx62, and Ixx76) can be tuned using the tuning utility in the Pewin32Pro2 software. Commutation, encoder feedback, phasing, and position loop tuning can then be setup for closed loop control.

Note

Complete closed loop setup procedure can be found in the pertaining hardware axis-interface, and Turbo User/Software reference manuals.

DRIVE COMMAND STRUCTURE

Default Mode

In default mode, the Geo Direct PWM Drive returns phases A and B current measurements as well as global and axis faults.

Caution

Failure to set the ADC strobe word correctly could result in damaging the drive's electronics.

The global and axes faults are in the lower 12 bits of ADC A, whereas the current measurements are in the upper 12bits of ADC A:

ADC A Data Register																							
23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Phase A Current Measurement												**Global and Axis Faults**											

The ADC Strobe word must be set up properly for the data to come back correctly (and proper operation):

PMAC Type	ADC Strobe Word	Value	ADC A data register
Non-Turbo	WX:$C0***1***4	$3FFFFF	Y:$C005
Turbo	I7***m***06	$3FFFFF	Mxx05
Power PMAC2	Gate1[***i***].AdcStrobe	$3FFFFF	Gate1[*i*].Chan[*j*].Adc[**0**]
Power PMAC3	Gate3[***i***].AdcAmpCtrl	$FFFFFC02	Gate3[*i*].Chan[*j*].AdcAmp[**0**]

Note

In normal mode operation, the ADC Strobe word has to be set for each Servo IC which has a PWM Drive attached to it.

Note

The ADC Strobe word can be saved with the SAVE command. It will be set automatically on the next power-up or normal reset.

Note

In default mode, ADC B does not contain any significant data.

Enhanced Mode

Enhanced mode enables access to and control of additional functions:

- Bus voltage reading
- IGBT temperature(s) reading
- Set PWM control for brush motor
- Turn Line Monitor off

Caution

The drive must be put in enhanced mode before accessing the additional functions.

Caution

Once the drive is set up for enhanced mode, do not set it back to default mode until the next logic power cycle.

PMAC Type	ADC Strobe Word	Enhanced mode	Additional Functions			
			IGBT Temp	Bus Voltage	PWM For Brush	Line Monitor Off
Non-Turbo	WX:$C0***1***4	$C00003	$800003	$880003	$A00013	$A00023
Turbo	I7***m***06					
Power PMAC2	Gate1[***i***].AdcStrobe					
Power PMAC3	Gate3[***i***].AdcAmpCtrl	$C0000204	$80000204	$88000204	$A0001204	$A0002204

With Power PMAC3, setting the drive to enhanced mode requires the following motor setting changes:

- Motor[x].PhaseCtrl = 4
- Gate3[i].Chan[j].PackInData = 0
- Gate3[i].Chan[j].PackOutData = 0

Note

Once in enhanced mode, the drive's communication will remain in enhanced mode until the next logic power cycle.

And the data is found in the lower 12 bits of ADC B for each axis:

PMAC Type	ADC B data register
Non-Turbo	Y:$C006
Turbo	Mxx06
Power PMAC2	Gate1[*i*].Chan[*j*].Adc[**1**]
Power PMAC3	Gate3[*i*].Chan[*j*].AdcAmp[**1**]

ADC B Data Register																						
23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Phase B Current Measurement												Enhanced Mode Data											

This is a read-modify-write register, once the drive is set up for enhanced mode, the following procedure can be followed to access additional information:

- Read the ADC B data register (i.e. query it in the terminal window)
- Set the strobe word to the desired command code of a function (i.e. Reading Bus Voltage)
- Read the lower 12 bits of ADC B to access the reported bus voltage value

Note

Subsequent additional information command code must follow the same procedure with the drive always in enhanced mode until the next logic power cycle.

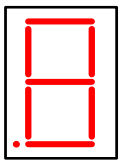
TROUBLESHOOTING

LED Status

LED	Description
ENABLE 1	➢ **Green** when axis 1 is enabled ➢ **Red** when axis 1 is not enabled ➢ **Unlit** does not necessarily mean a faulty condition
ENABLE 2	➢ **Green** when axis 2 is enabled ➢ **Red** when axis 2 is not enabled ➢ **Unlit** does not necessarily mean a faulty condition
BUS	➢ **Red** when bus is connected (capacitors are charged) ➢ **Unlit** when bus is not connected (capacitors fully discharged)
SHUNT	➢ **Yellow** when the drive is dissipating power ➢ **Unlit** when the drive is not dissipating (most cases)
+5V	➢ **Green** when 5 VDC power is present ➢ **Unlit** indicates that the 5VDC is not present (failure condition)
GATE ENABLE	➢ **Green** when the gate is enabled ➢ **Unlit** when the gate is disabled

7-Segment Display

The Global and Axis faults are interpreted by the Amplifier processor(s) and sent to the 7-segment 3-character scrolling display (D1 amp status).



The blinking dot is the heartbeat of the drive processor(s) and is always active in normal mode operation. It is turned off or not blinking when the drive is in reset mode (reloading firmware) or has no logic power.

The display is blank if there are no axes enabled, and no faults. It shows a 0 if any of the axes are enabled, this is the normal mode operation. Not all errors reflect a message back to the PMAC. In these cases, the error is only sent to the Status Display.

Note

The Geo Drive disables (kills the output to the motors) automatically at the occurrence of a fault.

The response of the Geo Drive to an error depends on the error's severity. There are two levels of severity:

- Warnings, simply called errors and not considered faults. They do not disable operation.
- Fatal errors which disable the drive's output to the motors, occasionally communication to PMAC

Error Codes

Display Code		Error / Fault Description	Description
AXIS 1	AXIS 2		
		Over Current RMS	Indicates that the I2T model, hard-coded in the amplifier processor projecting current output over time, has been violated within the operating current specification range of the amplifier.
		Over Current Peak	Indicates that an excessive amount of current (exceeding the specs of the amplifier) has been detected through the motor leads. This could be due to a shorted motor lead or a current/voltage surge.
		PWM Over Frequency	Indicates that the PWM frequency has exceeded the permissible limit. This can occur if the clock settings are incorrect, or the presence of a bad PWM cable.
		IGBT Over Temperature	Indicates excessive IGBT temperature (close to 75 ºC) has been detected. Power off the drive and let it cool down. Check cabinet ventilation, and fan functionality. Check for blocked airflow.
		Motor Thermal Relay	Indicates that the normally closed Motor Thermal contact (connector X3) is in open circuit.

Display Code	Error / Fault Description	Troubleshooting Notes
		GLOBAL
	Normal Mode Operation	➢ No faults reported
	Over Voltage	➢ The bus voltage has exceeded the permissible threshold: 420 VAC for GPL Drives 820 VAC for GPH Drives ➢ Make sure that the external shunt is connected properly. ➢ Make sure that the AC input is not excessively over spec.
	Under Voltage	➢ No bus voltage input. ➢ Bus voltage has dropped below the permissible threshold (97 VAC).
	Shunt Regulator	➢ Shunt resistor leads or pins shorted. ➢ Internal shunt regulator resistor failure.
	Ground Short	➢ Motor leads shorted. ➢ Shunt resistor leads or pins shorted.
	Gate Driver	➢ Motor leads shorted ➢ Shunt leads or pins shorted ➢ Gate driver (internal) failure.
	Line Monitor	➢ AC line voltage is low or not present.

APPENDIX A: CABLE/CONNECTOR KITS

PWM Cables

Option	Cable Length	Part Number
CABPWM-1	24” (600 mm)	200-602739-024X
CABPWM-2	36” (900 mm)	200-602739-036x
CABPWM-3	60” (1.5 m)	200-602739-060x
CABPWM-4	72” (1.8 m)	200-602739-072x
CABPWM-5	84” (2.1 m)	200-602739-084x
CABPWM-6	144” (3.6 m)	200-602739-144x

Note

PWM cables are compatible with all models of the Geo Direct PWM Drives.

Connector Kits

Part Number	Model	Description
CONKIT1A	Gxx012xx Gxx032xx Gxx052xx GxL102xx	Molex Connectors for **2** axes, AC input, and 24 VDC input.
CONKIT1C	Gxx051xx	Molex Connectors for **1** axis, AC input, and 24 VDC input.
CONKIT2A	GxH102xx Gxx152xx	Molex Connectors for **2** axes, AC input, and 24 VDC input.
CONKIT2C	Gxx101xx Gxx151xx	Molex Connectors for **1** axis, AC input, and 24 VDC input.
CONKIT4A	Gxx201xx Gxx301xx	Molex Connectors for **1** axis (4 pins), AC input (4 pins), and 24 VDC input.

Note

The connector kits require Molex Crimping tools for proper installation.

Cable Kits

Part Number	Model	Description
CABKIT1B	Gxx012xx Gxx032xx Gxx052xx GxL102xx	Molex mating connectors pre-crimped for **2** axes: ➢ 3 ft. AC Input Cable ➢ 3 ft. 24 VDC Power Cable ➢ 10 ft. shielded Motor Cables
CABKIT1C	Gxx051xx	Molex mating connectors pre-crimped for **1** axis: ➢ 3 ft. AC Input Cable ➢ 3 ft. 24 VDC Power Cable ➢ 10 ft. shielded Motor Cables
CABKIT2B	GxH102xx Gxx152xx	Molex mating connectors pre-crimped for **2** axes: ➢ 3 ft. AC Input Cable ➢ 3 ft. 24 VDC Power Cable ➢ 10 ft. shielded Motor Cables
CABKIT2D	Gxx101xx Gxx151xx	Molex mating connectors pre-crimped for **1** axis: ➢ 3 ft. AC Input Cable ➢ 3 ft. 24 VDC Power Cable ➢ 10 ft. shielded Motor Cables
CABKIT4B	Gxx201xx Gxx301xx	Molex mating connectors pre-crimped for **1** axis: ➢ 3 ft. AC Input Cable (4 pins) ➢ 3 ft. 24 VDC Power Cable ➢ 10 ft. shielded Motor Cables (4 pins)
G14AWG	Gxx051xx Gxx101xx Gxx151xx Gxx012xx Gxx032xx Gxx052xx Gxx102xx Gxx152xx	Extended cable length. Per foot per cable for the CABKITs. Customer must specify length.

Note

Cable kits have terminated cables on the drive end and flying leads on the other.